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Nutrition quality of pregnant women based on body mass index and the content of selected nutrients and energy in the daily diet

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ABSTRACT

Objectives: BMI of pregnant women is influenced by the percentage of energy and the content of individual nutrients in the daily diet. The aim of the study was to evaluate nutrition quality based on BMI values of women with physiological course of pregnancy and to determine correlations between BMI and the content of selected nutrients and energy in the daily diet.

Material and methods: The study was carried out among healthy women between the first and fourth day after childbirth. It was conducted using a standardized questionnaire of the National Health Institute: DHQ II. In total, 103 women met the inclusion criteria. The analyses were performed with the use of a data analysis software system called Statistica 10.0.

Results: The mean BMI before pregnancy was 22.30 ± 3.19 kg/m^2. The mean BMI before delivery was 27.87 ± 3.9 kg/m^2. The analysis of selected nutrient intake in relation to the nutritional status based on BMI before pregnancy showed no statistically significant differences. It was found that women with normal BMI (18.5–24.9 kg/m^2) consumed foods of lower energy value than those with BMI over 25 kg/m^2. These differences were statistically significant for daily energy intake and for the mean content of carbohydrates in the daily diet. Intake of selected nutrients was correlated in a statistically significant way with the nutritional status during pregnancy based on pre-partum BMI values. The higher the percentage of energy in the daily diet, the higher the pre-partum BMI values. Similar correlations were found for total fats, carbohydrates, protein, saturated fatty acids, mono- and polyunsaturated fatty acids, calcium, magnesium, vitamin D, water contained in foods, fluids and total sugars.

Conclusions: Dietary energy and carbohydrate content has a significant impact on BMI of pregnant women. During pregnancy, BMI increases with an increase in saturated fatty acid consumption. Intake of selected nutrients was correlated in a statistically significant way with the nutritional status during pregnancy based on BMI values.

Key words: nutrition in pregnancy; nutritional status of pregnant women; DHQ II

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INTRODUCTION

The quality of women's nutrition before and during pregnancy as well as their eating habits are becoming the main determiners of external factors affecting the course of pregnancy [1]. Nutrition during pregnancy affects fetal growth, birth weight and morbidity [2]. Body weight before pregnancy and weight gain during pregnancy play a significant role in normal fetal development. Studies based on body mass index (BMI) indicate that 10% of women younger than 30 years of age are malnourished before conception (BMI < 18.5 kg/m^2), whereas the percentage of obese and overweight women increases with age to 50%. Fewer than 50% of women change their eating habits during pregnancy, but this is not always related with improved diet adjusted to requirements, which increases the risk of vitamin and nutrient deficiency. Pregnancy is one of natural causes of weight gain, but uncontrolled, excessive weight gain is a significant risk factor of complications during pregnancy, childbirth or puerperium [3–5].

Aim of study

The aim of the study was to evaluate nutrition quality in women with physiological course of pregnancy according to their BMI values and to determine correlations between

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BMI and the content of selected nutrients and energy in their daily diet.

MATERIAL AND METHODS

The study enrolled healthy pregnant women aged 18–38 years (mean age 29.9 ± 3.89 years) and was conducted in the period between the first and fourth days post-labor in maternity units of hospitals in the Silesian Province of Poland.

The study was conducted using a standardized questionnaire of the National Health Institute: Diet History Questionnaire (DHQ II), and an author's own survey. The standardized DHQ II questionnaire evaluates eating habits in the past 12 months. That is why the authors enrolled women directly after the conclusion of a physiological pregnancy. DHQ II was prepared based on food intake reports generated in the Diet* Calc program version 1.5.0 [6].

DHQ II is an available food frequency questionnaire (FFQ) prepared by the team from the Risk Factor Monitoring and Methods Branch (RFMMB). DHQ II contains a list of food products updated according to the current nutrition data and consists of 134 questions concerning food products and eight questions concerning dietary supplements. Data obtained from a paper version of DHQ II were analyzed in the Diet* Calc program. This program enables one to interpret data from DHQ II and determine estimated intake of individual food groups and nutrients [6]. The Diet*Calc provided reports on estimated daily intake of nutrients, energy, micro- and macroelements and the remaining food components. The reports contain a list of 176 nutrients and food groups.

Data analysis/statistical methods

Statistical hypotheses were verified with the significance level of $p < 0.05$. Significance of the differences between groups was evaluated based on the Student's T test or, in the case of a higher number of groups, analysis of variance (ANOVA). The analyses were performed with the use of a data analysis software system called Statistica 10.0.

The analysis included 103 women who met the following inclusion criteria: age 18–38 years, physiological course of pregnancy, pre-pregnancy BMI below 30, consent to participation and correctly completed questionnaire (100% of main questions). The BMI index was calculated twice: before pregnancy and before labor.

RESULTS

The first BMI measurement was based on body weight before pregnancy, and the second on body weight before labor. The mean body weight before pregnancy was 60.76 ± 8.86 kg, and during pregnancy (measured before labor): 75.74 ± 10.11 kg. The mean pre-pregnancy BMI was 22.30 ± 3.19 kg/m^2, and the mean BMI measured for the last time before childbirth was 27.87 ± 3.9 kg/m^2. Considering the pre-pregnancy body weight, the group was divided into three subgroups based on the international classification of underweight, overweight and obesity according to BMI (WHO): underweight women (BMI < 18.5), normal body weight women (BMI 18.5–24.9) and overweight women (BMI: 25.0–29.9). Women with pre-pregnancy obesity (BMI ≥ 30.0) were excluded from the study. In the analyzed group, pre-pregnancy BMI was normal in most of the women (68.9%), 8.7% were underweight and 22.3% were overweight. Before delivery, 29.1% of women had the correct body weight (BMI ranging from 18.5 to 24.9 kg/m^2), 41.7% were overweight (BMI 25.0–29.9 kg/m^2) while BMI ≥ 30.0 kg/m^2 was found in 29.1% of the respondents. The analysis of BMI values before and during pregnancy showed that the mean pre-pregnancy BMI value was lower in a statistically significant way ($p < 0.05$) than BMI during pregnancy (22.30 ± 3.19 kg/m^2 vs 27.80 ± 3.66 kg/m^2). Weight gain during pregnancy was 14.99 ± 4.90 kg. Weight gain in pregnant should follow IOM guidelines and refer to pre-pregnancy BMI. The analysis showed that the higher the pre-pregnancy BMI level, the greater the pregnancy weight gain. The study showed statistically significant differences in individual BMI groups before pregnancy and before delivery (Tab. 1).

The analysis of selected nutrient intake in relation to the nutritional status before pregnancy based on BMI showed no statistically significant differences. However, the data indicate quantitative differences between intake of individual nutrients in relation to BMI. Women who were overweight (based on BMI) before pregnancy consumed foods of a considerably higher energy value compared with underweight women or women with normal body weight (2951.48 ± 1247.93 kcal vs 2001.33 ± 613.51 kcal and 2576.35 ± 1215.83 kcal). The energy value of food consumed daily before pregnancy averaged 2,609.9 ± 1,199.86 kcal. The comparison in terms of the remaining nutrients shows that overweight women consumed the greatest amount of fat (102.76 ± 48.65 g), protein (101.83 ± 47.62 g), carbohydrates (420.18 ± 205.39 g), cholesterol (313.48 ± 151.87 mg), saturated fatty acids (SFA) (37.45 ± 17.82 g), monounsaturated fatty acids (MUFAs) (35.78 ± 18.38 g) and polyunsaturated fatty acids (PUFAs) (20.65 ± 12.81 g) in their daily diet (Tab. 2).

Table 1. Nutrition status of women before and during pregnancy (body mass index before and during pregnancy)

Nutritional status based on BMI	Mean ± SD	Min–Max	p (Shapiro-Wilk test)
BMI before pregnancy	22.30 ± 3.19	16.4–29.7	0.00220
BMI before labor	27.80 ± 3.66	21.1–36.2	0.00332

p — level of significance; SD — standard deviation; BMI — body mass index

The analysis of the nutritional status during pregnancy according to BMI (measured before labor) in relation to the level of selected nutrients and energy (collective data) is shown in Table 3.

When analyzing the level of nutrient intake and the percentage of energy in the daily diet in different subgroups of women depending on BMI measured during pregnancy, it was found that women with normal BMI (18.5–24.9 kg/m^2) consumed foods of lower energy value than those with BMI over 25 kg/m^2.

Pregnant women with normal BMI (measured before delivery) consumed fewer calories (2193.0 ± ± 887.28 kcal) compared with those with overweight or obesity according to the pre-partum BMI values. Women with BMI ≥ 30 (3004.63 ± 1156.49 kcal) were characterized by the highest energy intake.

The situation is similar for the remaining nutrients. Apart from alcohol consumption and percentage of energy from fats, women with the lowest BMI consumed foods with a lower nutrient value than women with BMI ranging from 25––29.9 kg/m^2 or with BMI ≥ 30 kg/m^2. These differences were statistically significant for daily energy intake (p = 0.030517) and for the average content of carbohydrates (p = 0.052135) in the daily diet. There were no statistically significant differences for other nutrients, but quantitative differences between patients with various BMI values were noted.

The highest % of energy is derived from carbohydrates (> 50%) and fats (over 30%). They are followed by protein (approximately 15%) and saturated fatty acids (approximately 12%).

There were no statistically significant differences in the percentage of energy derived from individual diet compo-

Table 2. Pre-pregnancy nutritional status according to body mass index and the percentage of nutrients and energy in the daily diet (collective data)

Energy Nutrients		Pre-pregnancy BMI			
	p	< 18.5 kg/m^2	18.5–24.9 kg/m^2	25.0–29.9 kg/m^2	Total
ENERGY_KCAL_USD/d	0.120009	2001.33 ± 613.51	2576.35 ± 1215.83	2951.48 ± 1247.93	2609.9 ± 1199.86
TOTAL_FAT_G_USDA/d	0.106986	67.47 ± 23.91	89.99 ± 42.01	102.76 ± 48.65	90.87 ± 42.97929
CARBOHYDRATE_G_USDA/d	0.240070	290.67 ± 111.26	363.48 ± 208.2	420.18 ± 205.39	369.78 ± 202.41
PROTEIN_G_USDA/d	0.121956	67.5 ± 27.8	90.91 ± 41.77	101.83 ± 47.62	91.3 ± 42.69
ALCOHOL_G_USDA/d	0.121472	0.2 ± 0.49	1.02 ± 1.79	0.41 ± 0.69	0.81 ± 1.55
CHOLESTEROL_MG_USDA/d	0.327650	229.1 ± 106.9	311.23 ± 164.42	313.48 ± 151.87	304.55 ± 158.03
TOTAL_SATURATED FATTY_ACID G/d	0.176772	23.74 ± 10.41	34.03 ± 19.54	37.45 ± 17.82	33.90 ± 18.74
TOTAL_MONOUNSATURATED_FATT G/d	0.163302	24.79 ± 8.24	31.24 ± 14.37	35.78 ± 18.38	31.69 ± 15.10
TOTAL_POLYUNSATURATED_FATT G/d	0.076744	12.92 ± 4.61	16.96 ± 8.03	20.65 ± 12.81	17.43 ± 9.25
%Energy from TOTAL_FAT	0.798575	30.92 ± 7.59	32.22 ± 6.14	31.54 ± 6.61	31.95 ± 6.32
%Energy from CARBOHYDRATE	0.714628	57.66 ± 9.48	55.34 ± 8.00	56.18 ± 9.61	55.73 ± 8.45
%Energy from PROTEIN	0.599670	13.37 ± 2.75	14.47 ± 2.66	14.34 ± 4.22	14.35 ± 3.06

BMI — body mass index; p — level of significance; d — day

Table 3. Nutritional status during pregnancy according to body mass index (measured before labor) and the average level of selected nutrients

Energy Nutrients Skłp	p	BMI before labor			
		BMI 18.5–24.9	BMI 25.0–29.9	BMI ≥ 30	Total
ENERGY_KCAL_USDA	0.030517	2193.0 ± 887.28	2625.30 ± 1339.24	3004.63 ± 1156.49	2609.87 ± 1199.86
TOTAL_FAT_G_USDA	0.068546	78.56 ± 32.28	90.21 ± 47.05	104.12 ± 43.70	90.87 ± 42.98
CARBOHYDRATE_G_USDA	0.052135	302.93 ± 137.70	375.26 ± 230.30	428.77 ± 200.15	369.78 ± 202.41
PROTEIN_G_USDA	0.105732	79.70 ± 31.97	91.21 ± 47.92	103.04 ± 42.19	91.30 ± 42.69
ALCOHOL_G_USDA	0.654246	0.71 ± 1.04	0.98 ± 2.12	0.68 ± 0.92	0.81 ± 1.55
CHOLESTEROL_MG_USDA	0.293446	271.20 ± 133.08	306.44 ± 183.43	335.2 ± 138.83	304.55 ± 158.03
%Energy from TOTAL_FAT_G_USDA	0.865717	32.47 ± 4.38	31.81 ± 7.33	31.64 ± 6.58	31.95 ± 6.32
%Energy from CARBOHYDRATE G USDA	0.788274	54.83 ± 6.32	56.10 ± 9.10	56.10 ± 9.48	55.73 ± 8.45
%Energy from PROTEIN_G_USDA	0.818819	14.65 ± 2.71	14.21 ± 2.84	14.24 ± 3.72	14.35 ± 3.07

BMI — body mass index

nents in pregnant patients taking into account the division based on BMI during pregnancy (measured before labor). However, it was observed that pregnant women with BMI in the range of 18.5–24.9 kg/m^2 consumed more energy with fats and protein compared with other groups. The percentage of energy derived from long-chain polyunsaturated fatty acids (PUFAs), which are considered one of the most important dietary components, was the highest in women with normal BMI and reached 6.69%. This value was the lowest in women with BMI ≥ 30 kg/m^2 and equaled 5.86%.

The study led to a conclusion that intake of selected nutrients is correlated in a statistically significant way with nutritional status during pregnancy based on pre-partum BMI values. The higher the percentage of energy in the daily diet, the higher the pre-partum BMI.

Similar correlations were found for total fats, carbohydrates, protein, saturated fatty acids, mono- and polyunsaturated fatty acids, calcium, magnesium, vitamin D, water contained in foods and fluids, and total sugars (Tab. 4).

Table 4. Correlations between the nutritional status during pregnancy according to body mass index (measured before labor) and intake of selected nutrients)

Nutrients	BMI during pregnancy
ENERGY	R = 0.2665, p = 0.0065
TOTAL FAT	R = 0.2338, p = 0.0175
CARBOHYDRATE_G_USDA	R = 0.2392, p = 0.0150
PROTEIN_G_USDA	R = 0.2377, p = 0.0156
ALCOHOL_G_USDA	R = 0.0011, p = 0.9911
CHOLESTEROL_MG_USDA	R = 0.1508, p = 0.1285
TOTAL_SATURATED_FATTY_ACID G_USDA	R = 0.2394, p = 0.0149
TOTAL MONOUNSATURATED FATTY ACIDS G_USDA	R = 0.2056, p = 0.0372
TOTAL POLYUNSATURATED FATTY ACIDS G_USDA	R = 0.1780, p = 0.0721
DIETARY_FIBER_G_USDA	R = 0.0978, p = 0.326
RETINOL_MCG_USDA	R = 0.1205, p = 0.225
VITAMIN_E_AS_ALPHA_TOCOPHEROL	R = 0.0496, p = 0.619
VITAMIN_K_MCG_USDA	R = 0.1194, p = 0.230
VITAMIN_C_MG_USDA	R = 0.1888, p = 0.056
CALCIUM_MG_USDA	R = 0.2314, p = 0.019
MAGNESIUM_MG_USDA	R = 0.2187, p = 0.026
IRON_MG_USDA	R = 0.0595, p = 0.551
ZINC_MG_USDA	R = 0.1390, p = 0.161
PFA_20_5_EICOSAPENTAENOIC_USDA	R = 0.2197, p = 0.026
PFA_22_5_DOCOSAPENTAENOIC_USDA	R = 0.2282, p = 0.020
PFA_22_6_DOCOSAHEXAENOIC_USDA	R = 0.2201, p = 0.026
CAFFEINE_MG_USDA	R = 0.0640, p = 0.521
BETA_CAROTENE_MCG_USDA	R = –0.0517, p = 0.604
FOLIC_ACID_MCG_USDA	R = –0.0586, p = 0.557
TOTAL_SUGARS_G_USDA	R = 0.2438, p = 0.013
VITAMIN_A_RAE_MCG_USDA	R = –0.0361, p = 0.717
WATER_G_NDSR	R = 0.3424, p = 0.000
VITAMIN_D_CALCIFEROL	R = 0.2173, p = 0.0275
CHOLINE_MG_NDSR	R = 0.1838, p = 0.063

BMI — body mass index; R — correlation coefficient; p — level of significance

DISCUSSION

The analysis of the percentage of energy in relation to pre-partum BMI values revealed that the highest energy % derived from carbohydrates was observed in women with BMI in the range of 25.0–29.9 kg/m^2 and ≥ 30 kg/m^2. Carbohydrates, sugar in particular, is a significant factor determining a BMI increase during pregnancy and excessive weight gain. Similar results were presented by Maslov [7]. Positive correlations were also observed by Diemert who found that increased weight gain and BMI in pregnant women accompanies an increase in energy content and carbohydrate intake [8].

It was observed that intake of total protein and protein of animal origin is positively correlated with an increase in the nutritional status according to the pre-partum BMI values. The content of vegetable protein does not affect the nutrition status, as evaluated by BMI. Similar results were presented by Ostachowska-Gąsior, who observed an increase in BMI values during pregnancy with increased consumption of animal protein [9].

As for recommendations concerning saturated fatty acid consumption in the studied groups with respect to BMI (measured before delivery), there were no statistically significant differences. Intake of saturated fatty acids exceeded 10% of dietary energy requirement, which was not consistent with current guidelines, as their maximum limitation is recommended [3, 10]. The percentage of energy from polyunsaturated fatty acids in the daily diet of the surveyed pregnant women based on their BMI (measured before delivery) averaged slightly more than 6% in women with BMI ranging from 18.5 to 24.9 kg/m^2 and 25.0–29.9 kg/m^2, with the minimum recommended value of 6% and the maximum value of 10% [11, 12]. Pregnant women with BMI ≥ 30kg/m^2 consumed less polyunsaturated fatty acids than recommended. A low percentage of these acids in the diet of pregnant women has also been observed by Wawrzyniak et al. [13]. Delivering more energy from fats than specified in the recommended referential norms during pregnancy can have adverse effects in the child in the form of, *e.g.*, lipid accumulation in the liver, atherosclerosis or insulin resistance [14].

Authors of various studies on nutrient content in the daily diet of pregnant women indicate deficiencies as the main causes of health-related complications. However, excessive consumption of nutrients is an equally dangerous situation.

Research shows that balanced diet during pregnancy is the main determiner of fetal programming [15]. According to Renault, obesity during pregnancy is caused by consumption of sugar and saturated fat. Limiting snacks, sweets and non-alcoholic beverages might protect pregnant women from excessive weight gain to a greater extent than following a given diet. However, research does not clearly specify which nutrient is primarily responsible for a BMI increase and obesity during pregnancy [16].

The results suggest that limiting dietary carbohydrates can have a greater impact on reducing weight gain during pregnancy than increasing protein content. Higher protein intake during pregnancy increases satiety and attenuates hunger. A reason for increased food intake may be the activation of the so-called "reward system" by consuming foods of high fat and sugar content. Reward system stimulation promotes overeating, thereby leading to energy homeostasis disorders and thus to higher intake of energy than is actually utilized [10, 17].

The present study investigated a BMI increase and correlations of selected nutrients in pregnant women. Studies on nutritional factors and body weight determiners during pregnancy are a significant aspect in light of a growing epidemic of obesity and attempts to optimize body weight during pregnancy.

According to WHO guidelines, nutritional counselling and education should be based on improving nutrition quality of pregnant women, adjusting individual nutrients and their optimal dietary content. Education should also encompass advice on possible supplementation, including iron and folic acid. Moreover, promotion of pro-health and elimination of anti-health behaviors, particularly in terms of tobacco, alcohol or psychoactive substance use, should be an important aspect of such education [18]. Nutritional errors made by pregnant women should be eliminated at the very beginning of pregnancy, and preferably even in the preconception period. That is why instructing pregnant women or those planning pregnancy is relevant as it is a form of early prophylaxis of complications resulting from improper nutrition. Nutritional education of pregnant women is a significant element of obstetric care. Its aim is to improve nutrition quality of women and health outcomes of both women and children.

CONCLUSIONS

Dietary energy and carbohydrate content has a significant impact on BMI in pregnant women. BMI of pregnant women increases with an increase in saturated fatty acid and carbohydrate intake. Total protein content in the daily diet and animal protein consumption were found to be positively correlated with a BMI increase during pregnancy.

Ethics approval and consent to participate

The study protocol was approved by the Ethics committee of the Hamburg State Board of Physicians (06.91.2011, PV3694) and conducted according to the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants.

Conflict of interest

None.

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